Smolt Responses to Hydrodynamic and Physical Characteristics of Forebay Flow Nets Upstream of Surface Flow Outlets, 2007

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Goal

Use fish behavioral responses to derive general design guidelines for hydraulic conditions that readily pass juvenile salmon at surface flow outlets (SFOs).

Model of the Wells Dam SFO, Mike Erho

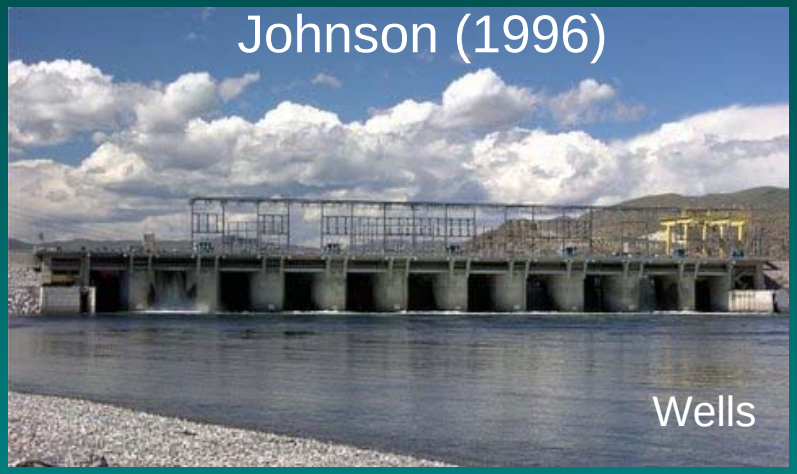
The Problem

Design guidelines for SFO entrance structures, and thereby the resulting forebay flow nets, are currently based on professional judgment.

Data on smolt responses to hydraulic conditions, however, could lead to structural designs that reduce costs while maintaining high entrance efficiencies.

An example of this problem is the issue of entrance shaping.

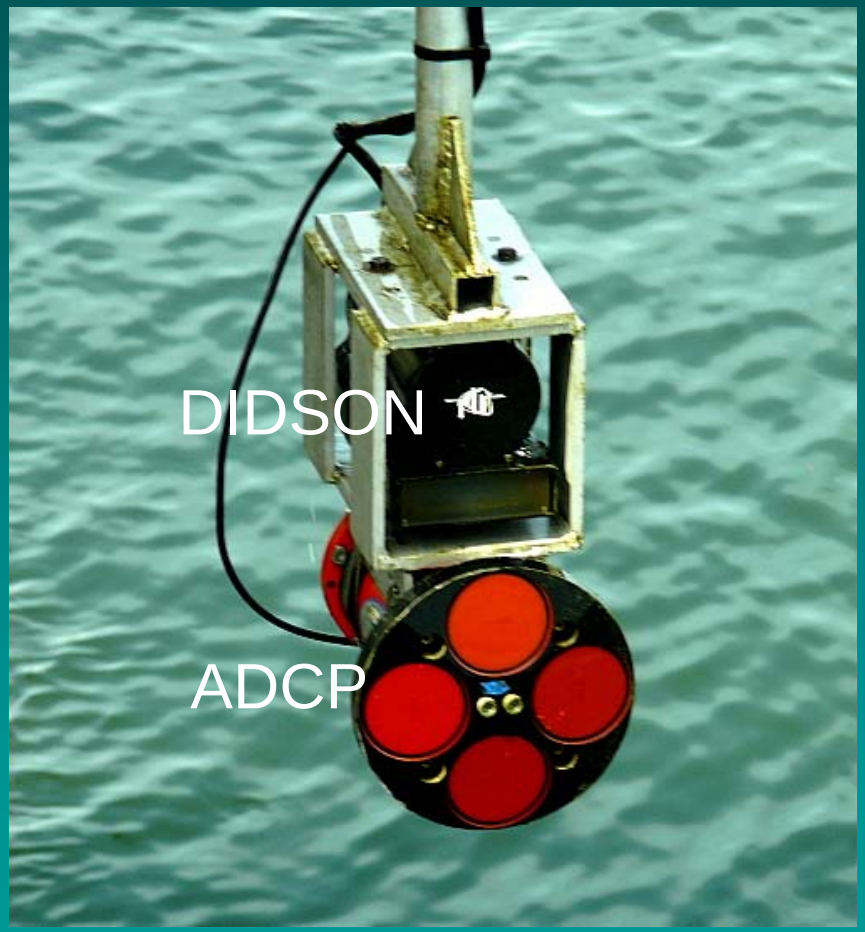
Previous Studies



Objectives

- McNary Dam -- Conduct a pilot study of simultaneous fish behavior and water velocity data in the nearfield (< 20 m) of a prototype Temporary Spillway Weir (TSW2) to:
  - establish the deployment procedure and collect preliminary data, and
  - assess the feasibility and potential for this technique to study smolt responses to hydrodynamics there.
- The Dalles Dam -- Apply new empirical data on fish behavior and water velocity from simultaneous remote sensing techniques in the nearfield of the sluiceway to:
  - characterize fish behavior and water velocity patterns,
  - examine associations between juvenile salmonid movements and hydraulic/physical conditions immediately upstream of the SFO entrances, and
  - establish a threshold in water acceleration or related variables in the flow net upstream of this SFO that results in juvenile salmonids rejecting the entrance.

General Approach



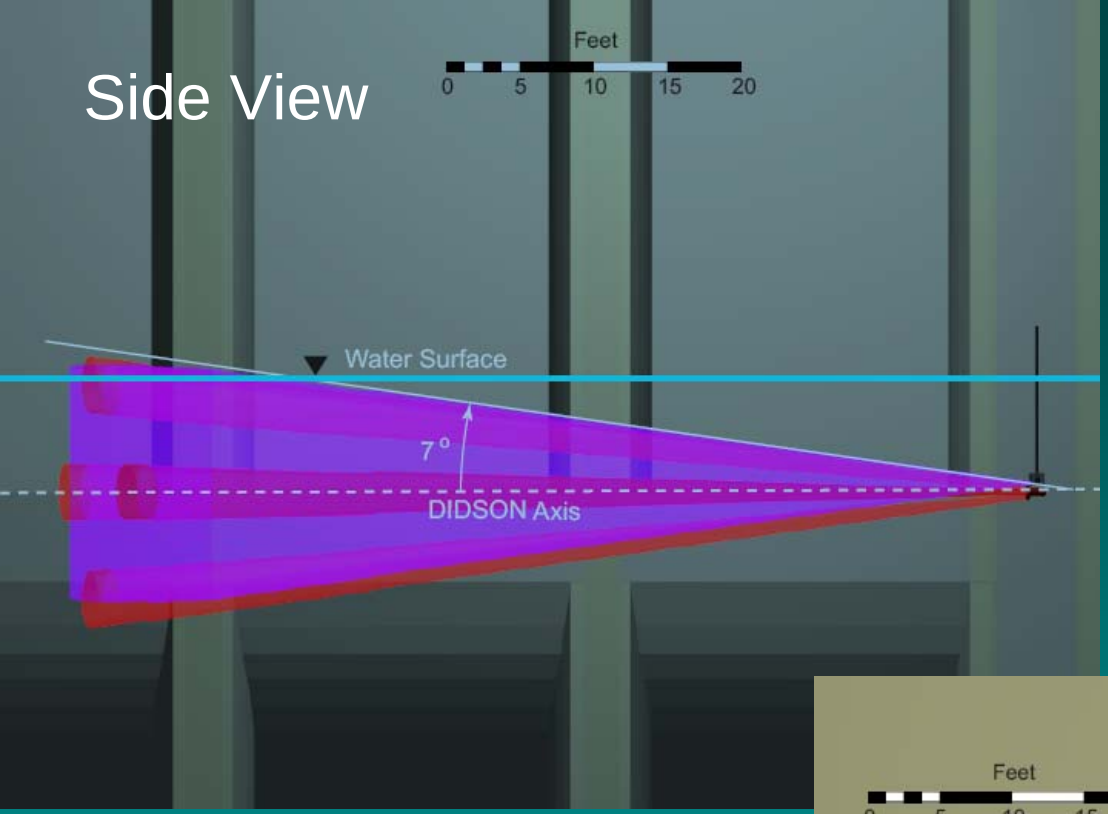
(Photo by R. Mueller)

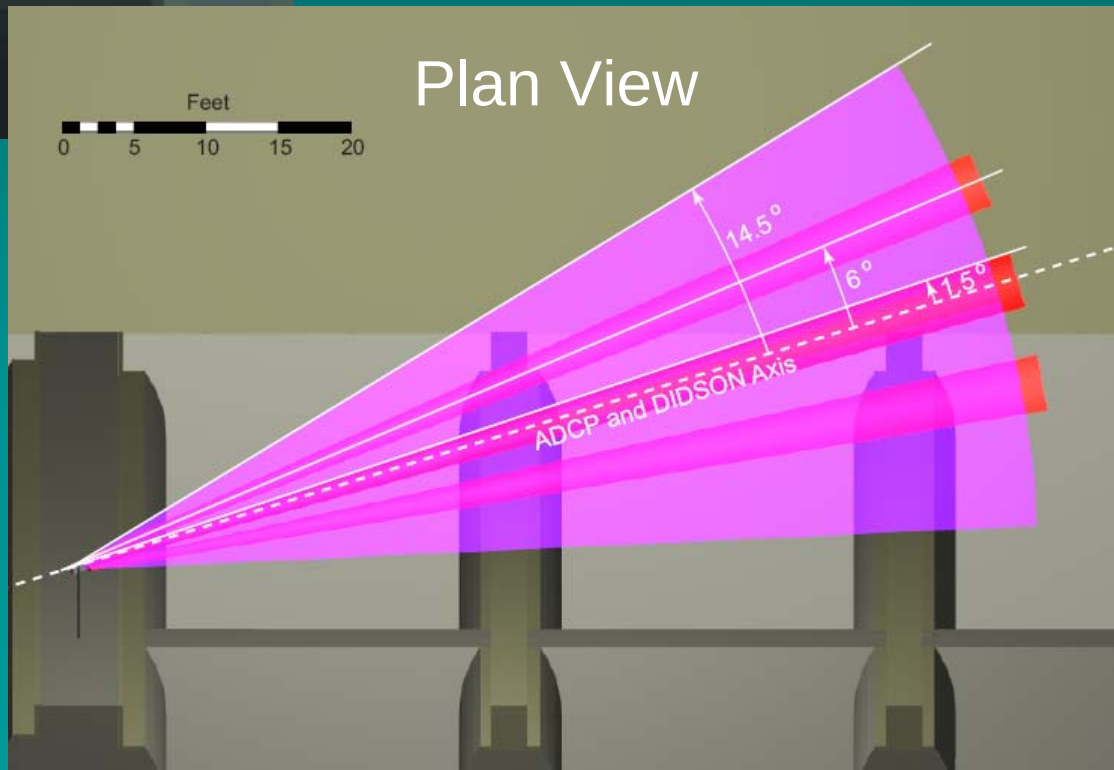
To achieve temporal and spatial synchrony between the physical and biological measurements to study relationships between fish and flow, we collected and merged simultaneous DIDSON (fish) and ADCP (water) data.

Instrument Features

- Acoustic Doppler Current Profiler (ADCP)
  - 600 kHz
  - “Narrow” foot print
  - Individual beams 3^{o}
  - Each beam 6^{o} off-axis
  - Sampling rate 1 Hz
- Dual-frequency Identification Sonar (DIDSON)
  - 1 MHz (“low” frequency)
  - 48 individual 0.6^{o} x 14^{o} beams
  - Sample volume 29^{o} wide x 14^{o} high
  - 7 frames per sec

Acoustic Beams



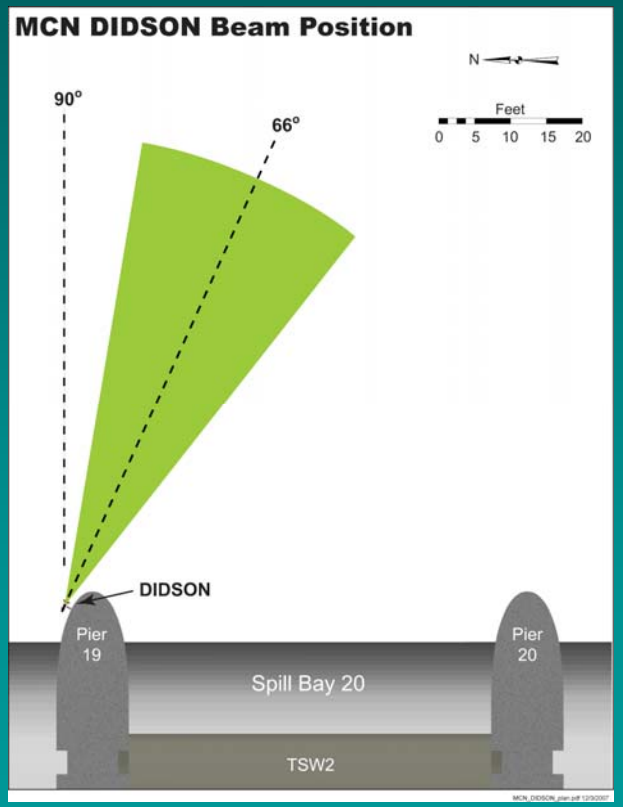


DIDSON – purple
ADCP -- red

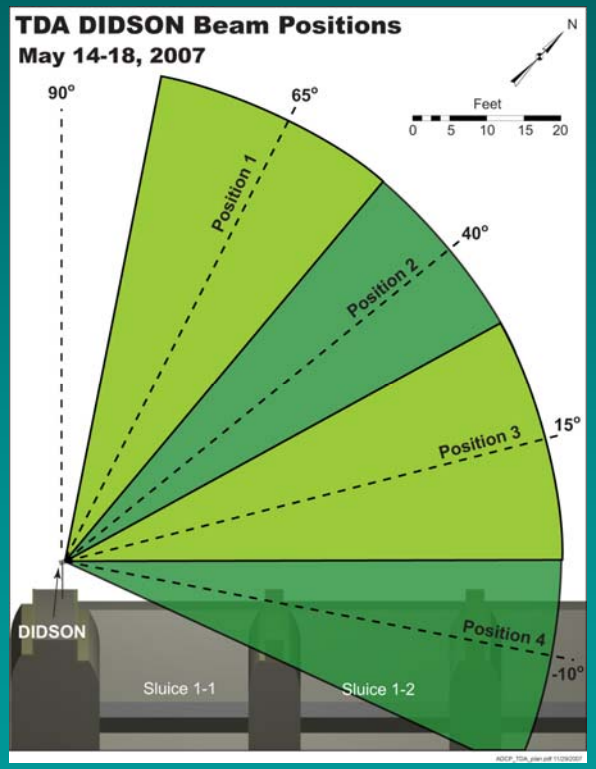
(Drawings by J. Serkowski)

Sample Zones
(Plan View)

McNary TSW2



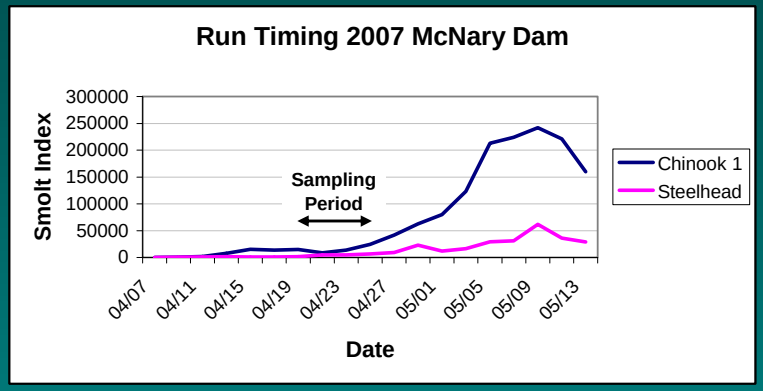
The Dalles Sluiceway



Sampling Schedule, Subset, and Species Composition

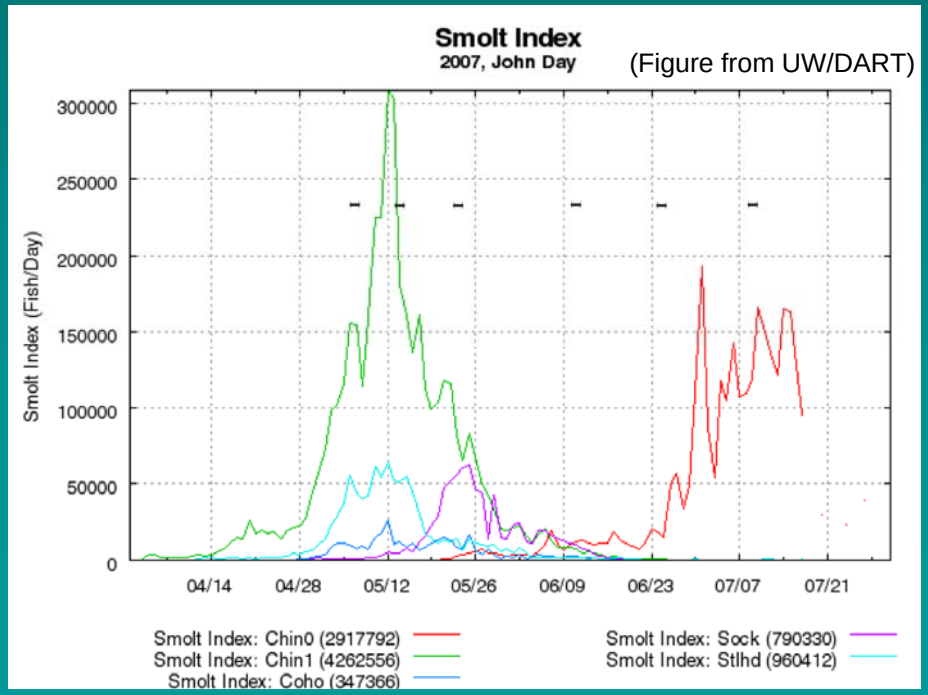
McNary Dam

4/23-26



The Dalles Dam

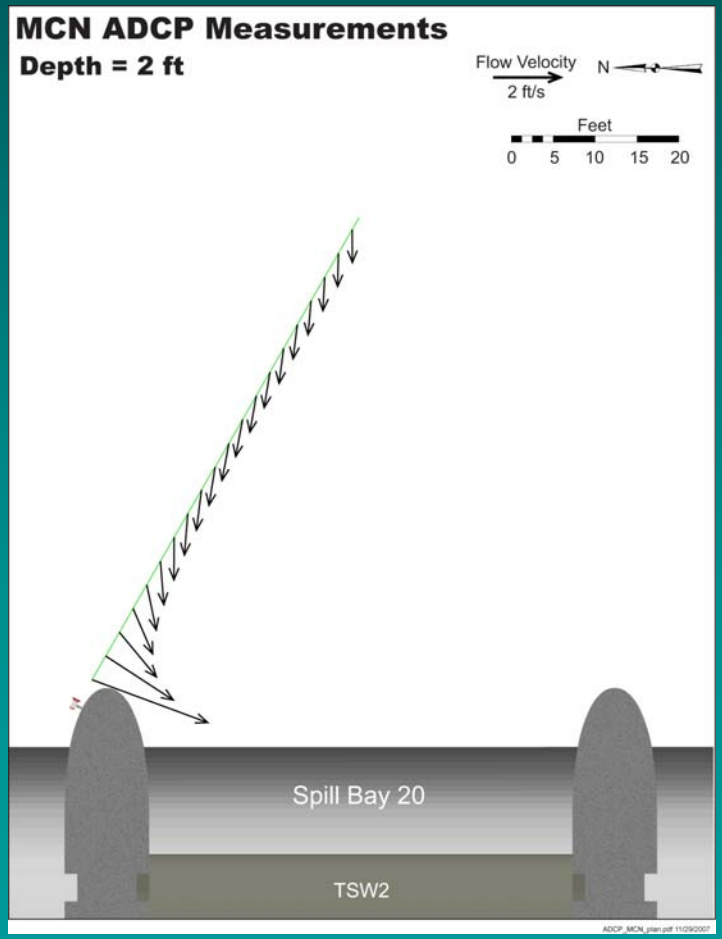
Season	Period	Dates
Spring	Early	May 1-4
	Middle	May 14-17
	Late	May 21-23, 26
Summer	Early	Jun 11-14
	Middle	Jun 24-27
	Late	Jul 9-12

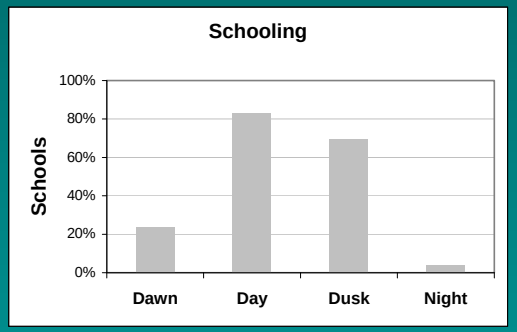


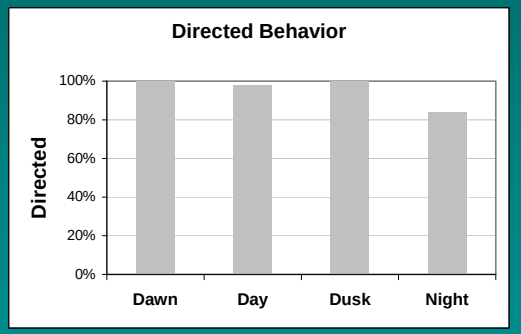
Variables

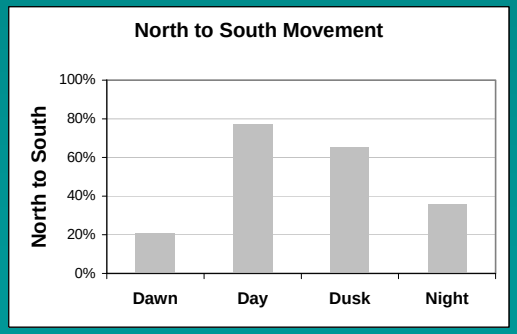
- Environmental
  - Season
  - Time of day
    - dawn, day, dusk, night
  - Distance from SFO
    - aiming positions 1-4
- Hydraulic
  - Velocity
  - Turbulence index
    - root-mean-square of velocity
  - Acceleration index
    - time derivative of velocity
  - Shear index
    - spatial derivative of velocity
- Fish Behavior
  - Schooling
    - yes or no
  - Directed
    - yes or no
  - Path
    - to sluice, east-to-west, etc.
  - Rejection
    - yes or no
- Fish Movement
  - Observed speed and direction
  - Swimming speed and direction

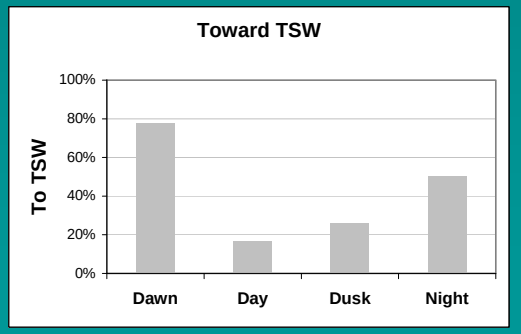
At MCN, surface flow moved toward TSW at 3-5 fps. Fish behavior was directed, more toward the TSW and with less schooling during night than day.



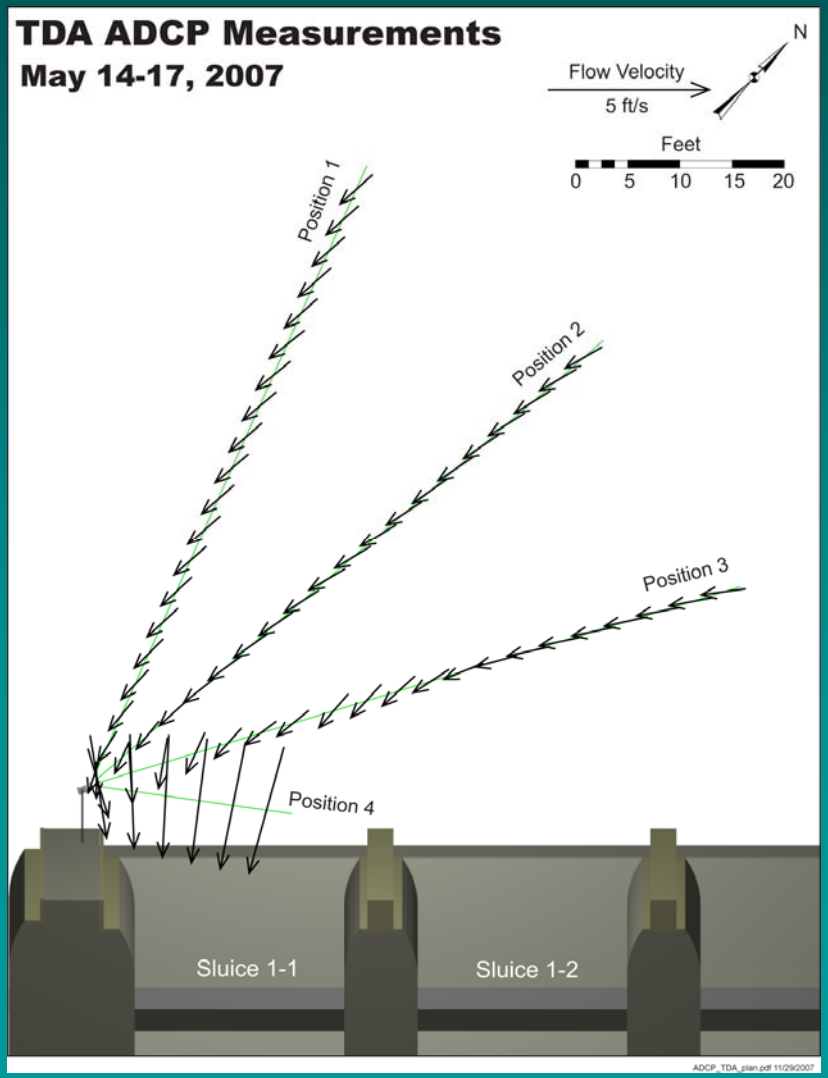




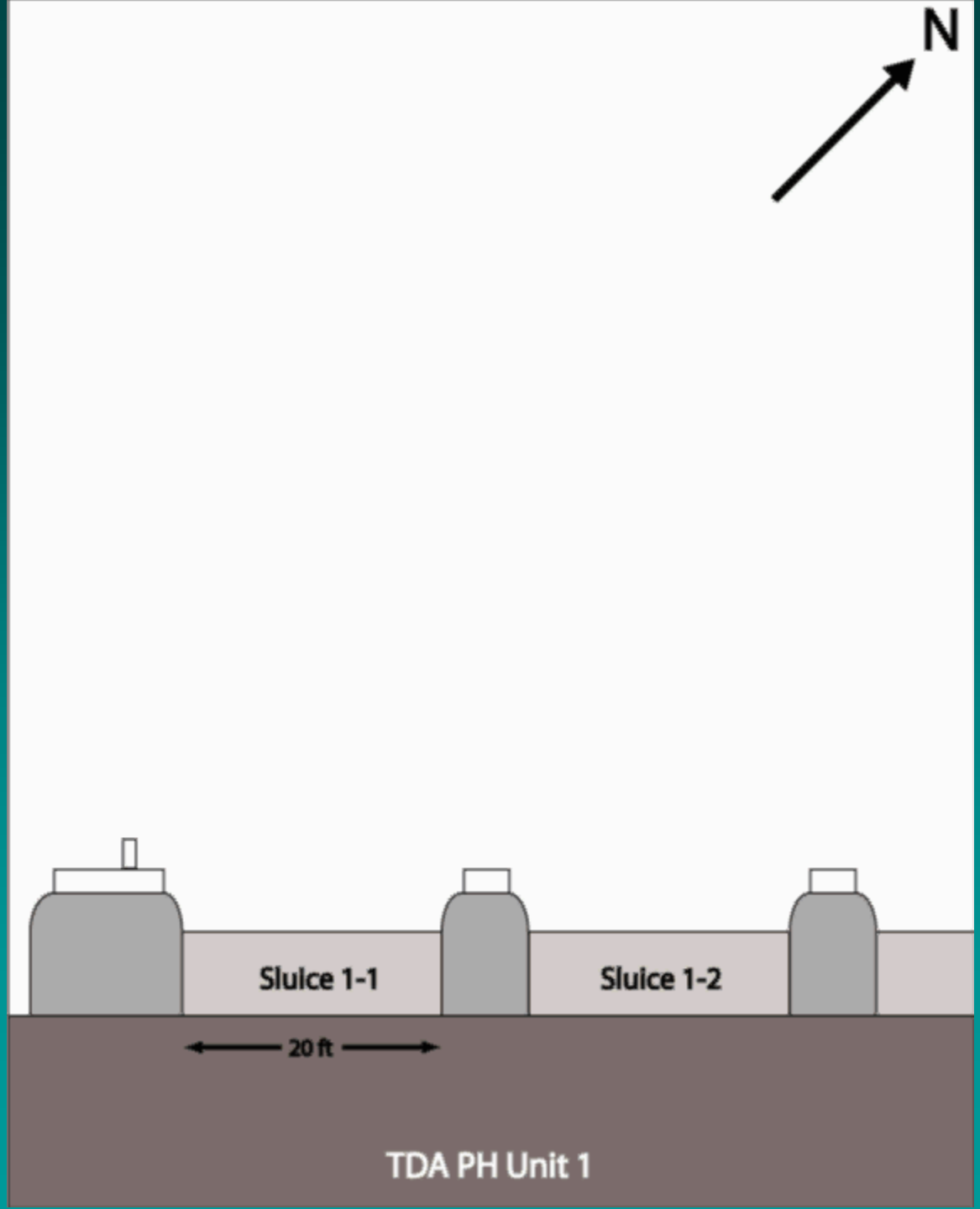




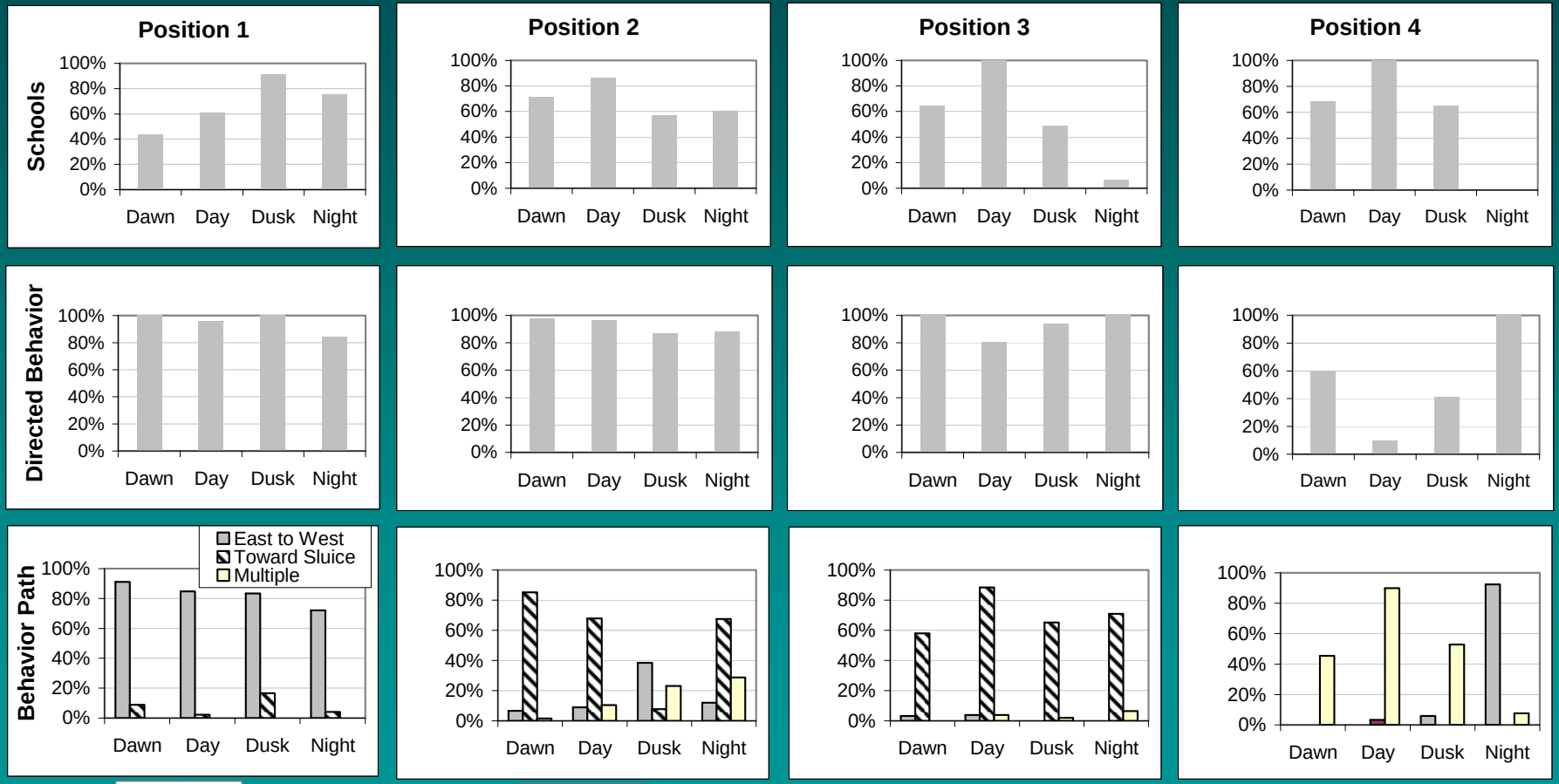
At TDA, water flowed along the dam from east to west then curves into the sluice. The data show increases in velocity near the sill.

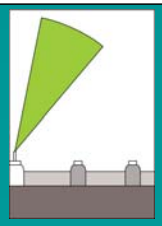


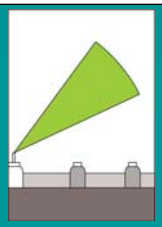
At TDA, fish behavior was complex. We observed individuals and schools of fish, direct and non-direct movement, and acceptance and rejection of the sluice entrance.



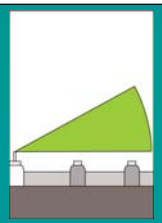
Fish behavior patterns varied by distance from the SFO (position) and time of day.







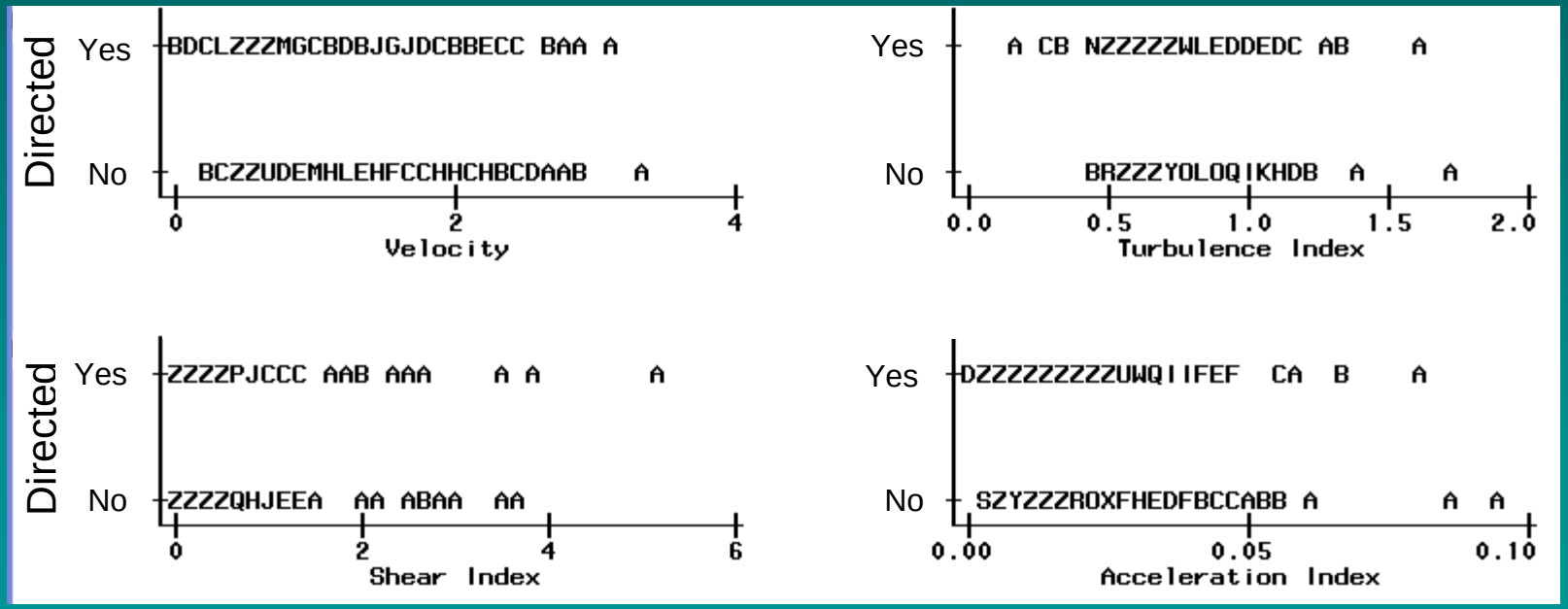
Data for
May 14-17.



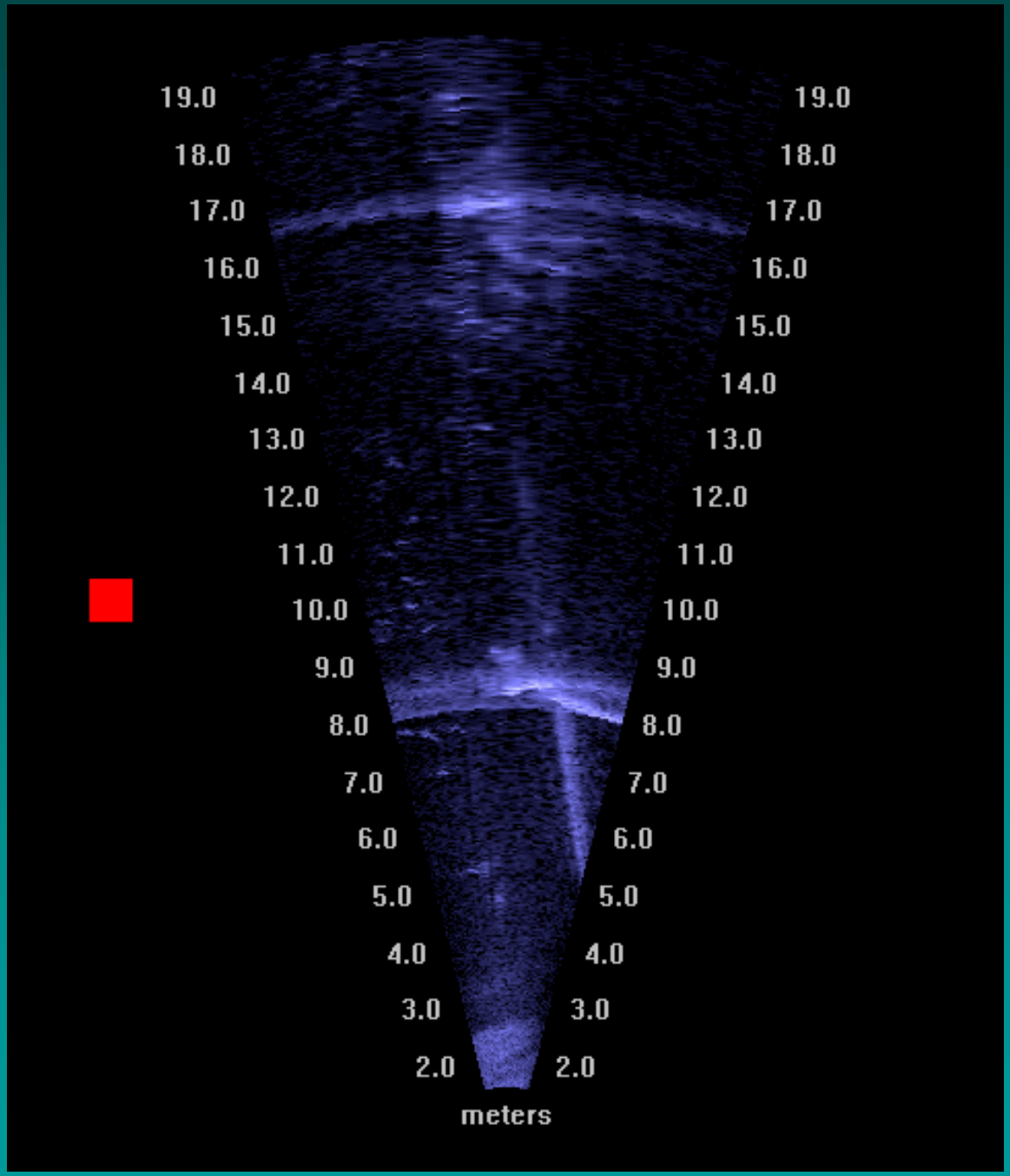
Directed behavior was not associated with particular hydraulic variables.

All aiming positions and sampling episodes and time periods combined

A= 1 observation, B=2, etc.



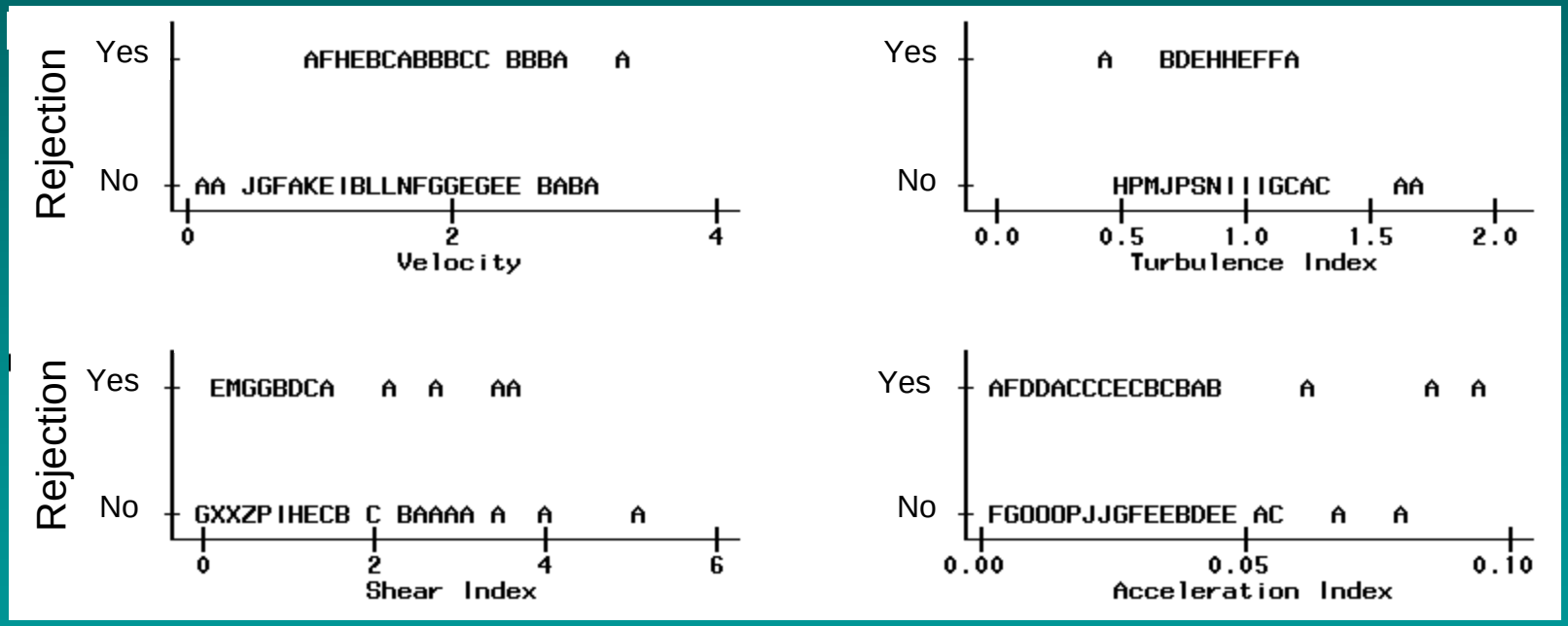
Individuals and schools of fish rejected and/or accepted the sluice entrance.



Rejection behavior was not associated with particular hydraulic variables.

Only Position 4 (sluice sill); data for episodes and time periods combined.

A=1 observation, B=2, etc.



Summary of Results by Objective

- MCN -- It is feasible to use this approach at a TSW at McNary Dam.
- TDA – Simultaneous ADCP and DIDSON were collected, merged, and analyzed.
  - Characterizations – Schooling behavior is common, especially during daytime. Directed behavior occurs under various environmental conditions.
  - Associations – Associations between fish behavior and hydraulic conditions were not apparent.
    - [Analysis using fish swimming effort as the response variable is underway.]
  - Threshold – TBD

Recommendation No. 1

In situ observations of fish behavior in the nearfield of prototype and production SFOs are an important component of an overall monitoring and evaluation program because it allows you to directly observe fish responses to the SFO flow net.

Therefore, continue Ploskey's SFO survey effort as new SFOs come on-line and synthesize results over multiple SFOs.

	'04	'05	'06	'07	'08	'09
B1		X				
B2	X	X				
TDA	X	X		X		
JDA					X	X
MCN				X	X	
IHR						
LMO						X
LGO						
LGR						

Recommendation No. 2

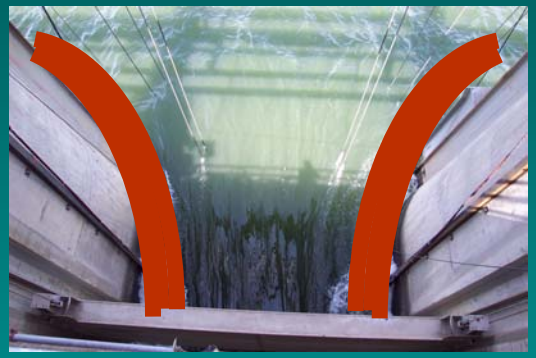
Consider research on fish response to a special SFO entrance structure in a rigorous experimental design.

For example, does entrance shaping matter? Deploy a PSW at The Dalles and, as Erho said, let the fish tell you.

Portable Sluiceway Weir (PSW)

w/o PSW

w/ PSW



Use the hammerhead crane to move the PSW in and out

How about those Beavers...